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THE HUMAN ROLE IN ADVANCED MANUFACTURING

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ABSTRACT

This paper discusses the performance and achievements of a wheel manufacturing plant. Kirton's adaption and innovation inventory (KAI) of the team behind it is analyzed. An adaptive team has brought out these changes. In this back-drop role of human being in advanced manufacturing, trends are enumerated.

KEYWORDS: Cast Wheels, Forged Wheels, KAI, Industry 4.0 & Society 5.0

NOTATIONS

KAI - Kirton's adaption and innovation inventory

RSC - National Academy of Indian Railways (erstwhile Railway Staff College, Vadodara)

S. D - Standard deviation

x - Mean

TTCI - Transportation Test Center Incorporation the USA

BG - Broad Gauge

MG - Meter Gauge

BOXN - Freight Stock of Indian Railways

RWF - Rail Wheel Factory (erstwhile Wheel and Axle Plant), Bangalore, India

Crore - One tenth of a Billion

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Original Article

INTRODUCTION

It is the responsibility [1] of the managers of the organization to understand the capacity of each employee and get the best results. Knowledge [2] does not mean collecting data or information, it is bringing out the latent potential of employees, sometimes in the form of slogans, metaphors, and symbols for continuous improvement

No employee can work in isolation, the best work comes out with the effort of the whole group. A number of attempts have been made from time to time to bring out the capacity of a worker in a group.

There are two types of people, 1-those who, when they are faced with a problem, work on already established lines. It may be customs, theories or practices. 2-whereas there are other types of people who mix the old with the new they learn from the old practices but think out of the box and do things differently. Kirton [3]

identified these cognitive styles of behavior and named them as adaptors and innovators. An organization needs both types of employees to make progress and many organizations are doing that. He developed an instrument or questionnaire to identify this style and measure the inventory of employee of an organization. Kirton's Adaptor and innovator are on a score which ranges from 32 to 160 and its mean is 96. It is a three-factor or subscale model [7] for originality/ idea generation, Efficiency and rule/group conformity (SO, E, R).

KAI score of an experienced person [4] does not change with time. Studies indicate that there is no relation between KAI score and the intelligence measure. An impulsive person has a greater tendency to score as an innovator in KAI. Both adaptors and innovators [5] may produce different quantities of novel ideas simultaneously.

If teams from different discipline are put together [6], they are found to be more innovative rather than those which are of the same discipline in a workplace.

KAI score data of trainees coming, from different levels of railway organization to National Academy of Indian Railways (erstwhile Railway Staff College) Vadodara India was analyzed [9]. It was concluded that the group estimates of an individual and that estimated by peer group have a positive relationship as reported in [8] also. Women both as managers and doctors are innovative but in the subordinate categories, they tend to be adaptive. It was found that railway managers with science and engineering background showed adaptive styles whereas those with an arts background have a mixture of adaptive and innovative styles.

Kathryn [10] explains problem-solving level and problem-solving styles. Problem-solving level is the mental resources or knowledge whereas problem-solving style is a person's preferred approach to solving problems. Thomas Edison had 1100 patents and Nikola Tesla had 700 patents. Both were innovators. Edison's was adoptive as compared to Tesla as he gave commercial value to each brilliant idea within a known area of work. Tesla's contributions were a diverse field such as hydropower generator, guided missiles. He was referred to as 'mad scientist'. Loftin's approach was to make aware individual's style in a team in order to tackle the problem with a minimum of conflicts.

This paper describes the systematic fourfold increase in production of cast wheels and its adoption in services, where reliable forged wheels were used. It analyses the cognitive level and styles of the team behind these performances.

MANUFACTURING OF WHEELS IN RWF BANGALORE, INDIA

Indian Railways runs every day 7500 freight trains and 13000 passenger trains, which is one of the largest networks in the world. Both the freight and passenger services are equally important.

Railroad wheels are manufactured either by directly casting from the liquid metal into finished shape or by forming from solid blocks of ingot through a sequence of the hot forging process.

The characteristics required for the passenger car and the locomotive wheels is reliability and that required for the freight car wheel is initial and maintenance cost. Forging gives a better finish and a good grain structure and therefore has been adopted for passenger car and locomotive wheels whereas cast wheels have been adopted for freight stock wheels.

RWF (Rail Wheel Factory) at Bangalore came up in 1978 at a cost of Rs. 178 crores. This production unit uses cast wheel technology of M/s Griffin USA and produces cast wheels for freight stock.

Initial capacity of RWF was 50,000 wheels of freight stock and now it has gone up to 200,000 p. a. This was possible by reducing bottlenecks, idle time, adopting parallel activities, multiple ladle operation and automation (including

changes from electromechanical control to digital control and robotics). Typical examples are Placement of mold on pouring tube, and transfer to the cooling bay after casting used to follow placement of next mold for casting was modified as the placement of next mold simultaneously with the transfer of mold with casting. It saved the time of each casting and finally time in each heat reduced and drop of temperature of molten metal came down. Sprue wash after cooling bay was manual and hazardous. It was automated as hot grinding using robotics. It reduced processing time.

Diversification of Cast Wheels

Locomotive and coaching stock wheels were forged wheels and were obtained from SAIL India and import as reliability was the prime consideration.

Experience of manufacture of cast wheels for freight stock and their performance was gained over years. There was no online failure of these cast wheels produced by RWF Bangalore. Therefore, the manufacturing process was adopted for Loco and Coaching wheels.

With this success locomotive and coaching stock wheels were also produced in 2000-2004. Initially these were having casting defects. Then casting simulation software was used to modify locations and size of risers. With these modifications casting produce were sound.

Thereafter finite element analysis using NISA software was done and these wheels were got tested at Transportation Test Centre Inc. (TTCI) the USA. Indian Railways uses multiple wear wheels. TTCI found FEA analysis ok and wheels very sound for use.

European Railroads have been experimentally confirmed the capability of cast wheel applications [11] and it has been implemented satisfactorily over Indian Railways.

Apart from manufacturing freight stock cast wheels (BOXN, Container flat), RWF Bangalore is also manufacturing coaching stock cast wheels of BG and MG, Locomotive wheels of BG and MG and suburban and intercity EMU cast wheels [12,13].

Production Over the Years

Table 1, gives the production of wheels from 1990to 2012, which has increased from 47K to 200K. It is shown in Figure 1 also.

Table 1: Production Over the Years

Year	1990	2000	2005	2009-10	2011-12
Wheels	47139	95591	117425	187480	201135

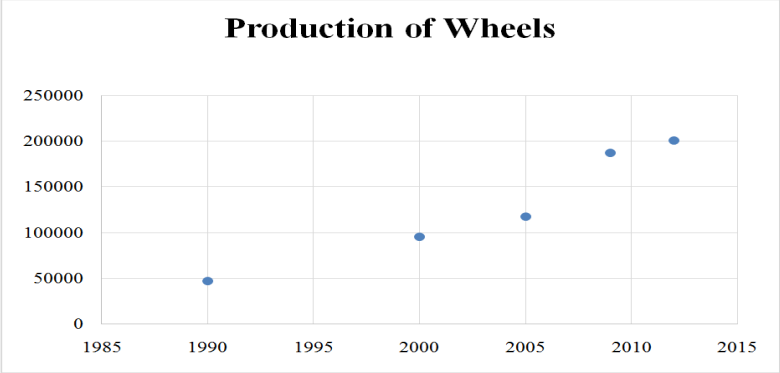

Figure 1: Production of Wheels

So far no online-failure of these wheels has taken place. In other words, these cast wheels are more reliable.

TEAM BEHIND THESE PERFORMANCE IMPROVEMENTS

All the managers and supervisors were briefed about KAI and subjected to identify their creative style in 2000. Weekly meetings helped in developing a platform of understanding of working of various wings in wheel manufacturing.

KAI scores of the team involved in the maintenance and operation of the Wheel production plant are given in Figure 2.

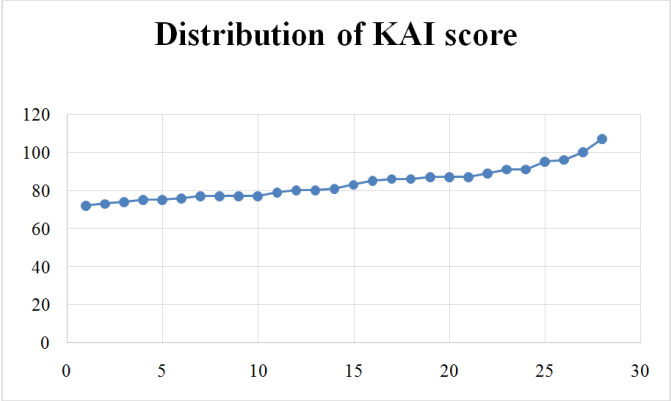

Figure 2: Individual KAI Scores of the Team Involved in the Maintenance and Operation of the Wheel

Table 2: Statistical Parameters of Population (Size 28)

KAI Score	Frequency
71-75	5
76-80	8
81-85	3
86-90	6
91-95	3
96-100	2
101-105	0
106-110	1
N	28
X	83.67
SD	8.73

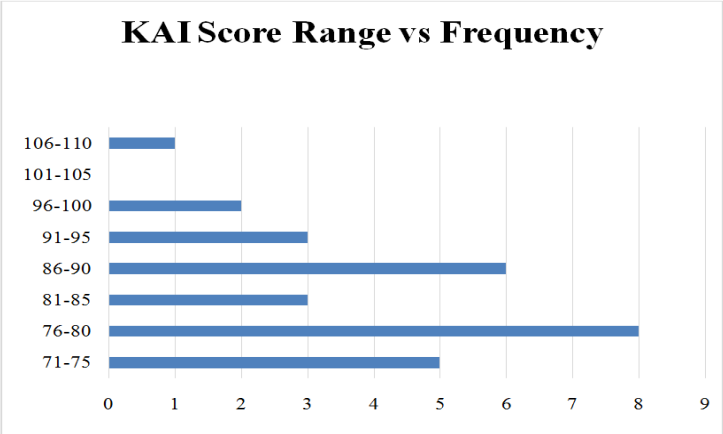

Figure 3: KAI Score Ranges and Their Frequencies

Table 3: Statistical Parameters in Respect of Discipline

S. No.	Group Description	Group Size	Max KAI	Min KAI	Mean KAI	SD
1	Managers	11	107	86	92.36	6.59
2	Mechanical Supervisors	12	86	76	79.83	3.35
3	Chemist Supervisors	5	75	72	73.8	1.30

Table 4: Statistical Parameters in Respect of Age

S. No.	Age Group	Frequency	Max KAI	Min KAI	Mean KAI	SD
1	34-39	5	100	87	90	6.34
2	40-44	5	91	86	86.2	2.22
3	45-49	4	77	73	75.25	1.71
4	50-54	5	107	72	88	14.4
5	55-58	9	96	74	81.33	7.16

DISCUSSIONS AND CONCLUSIONS

Overall Pattern

Table 3 gives max, min, mean and SD of the group. Figure 2 shows the individual KAI score and Figure 3 shows the frequency distribution with KAI score ranges. The maximum KAI score is 107 and the minimum is 72. The mean KAI score is 83.67, which indicative of the adaptive style. The SD is 8.73.

Discipline Wise Pattern

Table 3 gives discipline wise group size, max, min, mean and SD. A Range of KAI in respect of managers is 86 to 107 and 76 to 86 in respect of mechanical supervisors and 72 to 75 in respect of chemist supervisors.

Age Wise Pattern

Table 4 gives age wise frequency, max, min. mean and SD. Youngest age group 34-39 has mean KAI of 90 and SD 6.34. Highest KAI 107 is in the age group of 50-54. Its mean is 88 with SD of 14.4 means it has wide variation. Min SD 1.71 is in 45-49 age groups.

Cognitive Level

Except KAI 96 and 107 all were working in RWF right from the beginning. Industrial data of innovation and creativity shows that the maximum number of suggestions per employee is received in Japanese industry and their

implementation rate is the highest. Further data collected in RWF shows that they are comparable to a Japanese industry.

In day-to-day working, it is a bottom-up approach in this plant. Unlike other Railway units, RWF has a positive approach. In 2006-07 alone sixty-six major modifications and developmental activities have been undertaken, which speaks of the innovative capability of the workforce of RWF. That is why a high growth rate of 23.4% during 2005-06 and 7.4% during 2006-07 has achieved in consecutive years on Year on Year basis.

In other words, the cognitive level that is experience and knowledge of present work environment and day to day problem solving are high.

CONCLUSIONS

Production of the wheel has gone up from 50K to 200K, a fourfold increase. Cast wheel has been introduced to the services, where forged wheels were considered worldwide to be more reliable. This technology has been transferred in the setting of another cast wheel plant at Chapra (Bihar, India).

The mean KAI score of the group was 83.67 (Table-3). Most of them are working in this plant right from the beginning, so they have adequate experience, knowledge of working of the plant. The group is highly adoptive. High production levels, diversification, and quality have been achieved by a highly adaptive group.

Cognitive aspect of human behavior is behind technological upgradation and performance of this manufacturing plant. Human role is beyond man hours, ergonomics, and safety [14].

Agriculture based society came into existence around 8000BC. It was the first wave of civilization [15]. Prior to it, human beings were migratory. The industrial revolution started during the 16th Century. Initially, it was confined to the west and later on it spread all over the world. This was the period of mechanization, time & motion studies, scientific management. This was a shift from muscle/ animal power to machines and it brought mechanical engineering as a prominent profession. It was the second wave of civilization [15]. The third wave was the use of Information technology which started around 1955. It improved quality and productivity. The gap between first and second wave was about 9500, whereas the gap between 2nd and third came down to less than 300 years.

Fourth revolution, [16] identifies the use of Cyber-Physical Systems (CPS), Internet of Things (IoT), Internet of services and Smart Factory with 3D-printing, Big Data, AI, collaborative Robots (CoBot). These are termed as Industry 4.0. Main attention is around technical aspects in the implementation of Industry 4.0.

In spite of all these human beings with creativity and cognitive styles with cooperation lies beyond these. The human being remains at the center stage and it is termed [17] as Society 5.0.

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